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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte QINBAI FAN

Appeal 2009-004576
Application 10/642,852
Technology Center 1700

Decided: April 26, 2010

Before EDWARD C. KIMLIN, PETER F. KRATZ, and MARK NAGUMO,
Administrative Patent Judges.

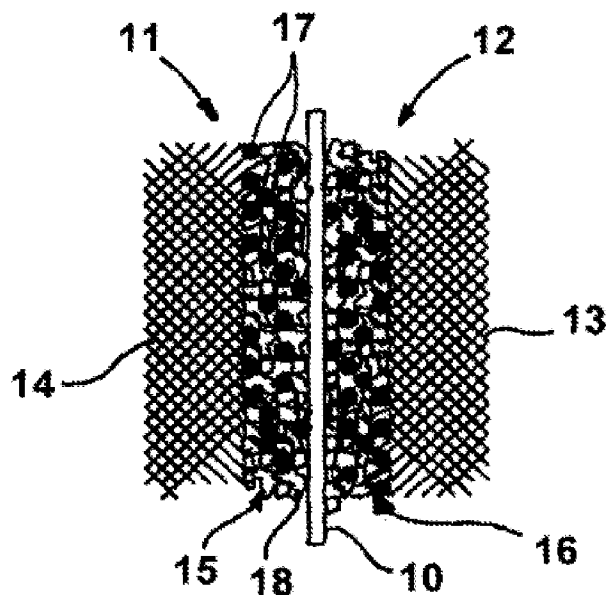
NAGUMO, *Administrative Patent Judge.*

DECISION ON APPEAL

A. Introduction¹

Qinbai Fan (“Fan”) timely appeals under 35 U.S.C. § 134(a) from the final rejection² of claims 1-14 and 40. We have jurisdiction under 35 U.S.C. § 6. We REVERSE.

The subject matter on appeal relates to improved polymer electrolyte membrane fuel cells that use carbonaceous fuels such as methanol, known as “direct methanol” fuel cells. (Spec. 3, ll. 12-14.) According to Fan, a conventional fuel cell has the structure shown in Figure 1, which is reproduced below:



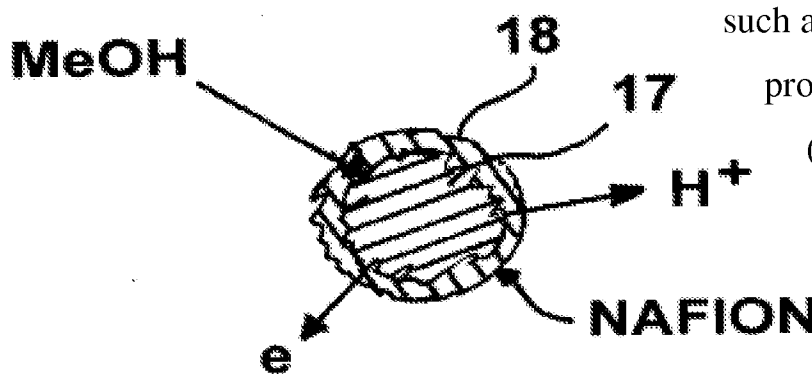
{Figure 1 is said to show a fuel cell}

¹ Application 10/642,852, *Direct Methanol Fuel Cell Electrode Catalyst*, filed 18 August 2003, claiming the benefit of a provisional application filed 6 May 2003. The specification is cited as “Spec.” The real party in interest is listed as Gas Technology Institute. (Appeal Brief, filed 29 February 2008 (“Br.”), 1.)

² Office action mailed 31 December 2007 (“Final Rejection”; cited as “FR”).

In the fuel cell, a solid polymer electrolyte (“PEM”) membrane 10 is disposed between anode electrode 11 and cathode electrode 12. (Spec. 7, ll. 20-21.) Each electrode comprises a current collector/gas diffusion layer 13, 14, which may be made of a carbon cloth. (*Id.* at 8, l. 1.) Between the diffusion layers 13, 14 and PEM 10 are catalyst layers 15, 16, which are typically applied directly on the gas diffusion layer or on the solid polymer membrane as a catalyst ink comprising catalyst particles 17 bound together by a binder material 18, typically NAFION. (*Id.* at ll. 4-7.)

Figure 2A, below, is said to depict a conventional catalyst particle encased by a thin layer of binder. According to Fan, typical binder polymers,



such as NAFION, conduct protons, but not electrons.

(Spec. 8, 6-7.) Thus, electron conduction from the catalyst particle 17 through the binder layer 18 must occur

Fig. 2A

via electron tunneling. (*Id.* at ll. 12-13.)

{Fig. 2A shows a conventional catalyst particle}

As a result, a limiting factor in the fuel cell performance is said to be the transport of electrons from catalytic particles 17 distant from the current collectors 13, 14. (*Id.* at ll. 16-18.) According to Fan, a further problem characteristic of direct methanol fuel cells, in which methanol is oxidized at the anode catalyst surface to produce CO₂, protons, and electrons, is the

passage of methanol molecules through the electrolyte membrane to the cathode side. There, the reaction of methanol with oxygen molecules reduces the fuel efficiency because fuel is lost at the cathode. (*Id.* at 9, l. 21 to 10, l. 3.) Moreover, the efficiency of the cell due to production of a reverse potential in the cell due to oxidation of methanol at the cathode. (*Id.* at 10, ll. 3-5.) The only place to stop the methanol passage is said to be in the anode catalyst layer and in the polymer electrolyte membrane. (*Id.* at ll. 8-10.) The anode gas diffusion electrode cannot be blocked because the anode needs the methanol to react. (*Id.* at ll. 8-12.)

The improvement for which exclusive patent rights are sought is based on providing a binder for the anode catalyst that conducts electrons and reduces or effectively eliminates methanol flow into or through the electrolyte membrane. Such an encapsulated catalyst particle is shown in Fig. 2B, reproduced below left. A preferred binder is an electron conductive polymer

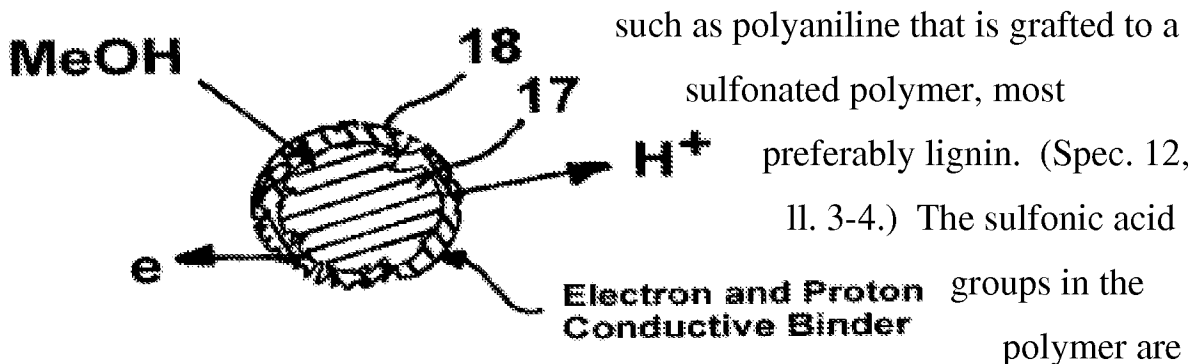


Fig. 2B

such as polyaniline that is grafted to a sulfonated polymer, most preferably lignin. (Spec. 12, ll. 3-4.) The sulfonic acid groups in the polymer are said to enable proton conductivity. (Spec. 13, l. 4.)

{Fig. 2B shows a catalyst particle of the invention}

According to Fan, the improvement yields fuel cells having higher catalyst efficiency and cell efficiency. The efficiencies are said to arise

because the electrons from the methanol oxidation are conducted to the external circuit without a tunneling step. (Spec. 13, ll. 4-6.) As a result, less catalyst (the most expensive component) is needed to obtain a given activity. (*Id.* at 14, ll. 4-6.) Moreover, the binder is said to be very stable towards oxidation and reduction because it is a grafted polymer. (*Id.* at 13, ll. 6-9.) Finally, the binder is said to reduce or effectively eliminate methanol flow into or through the electrolyte membrane, making the improvement especially effective for direct methanol fuel cells. (*Id.* at 10, l. 17 - 11, l. 2.)

Representative Claim 1 is reproduced from the Claims Appendix to the Principal Brief on Appeal:

In a fuel cell comprising an anode electrode, a cathode electrode and a proton exchange membrane electrolyte disposed there between, the improvement comprising:

an anode catalyst layer disposed on one of an
electrolyte facing surface of said anode electrode and
an anode electrode facing surface of said electrolyte,
said anode catalyst layer comprising
a proton conductive material and
an electron conductive material
substantially uniformly dispersed throughout
said catalyst layer,
at least one of said proton conductive material and
said electron conductive material comprising
lignin.

(Claims App., Br. 18; paragraphing and indentation added.)

The Examiner has maintained the following ground of rejection:³

- A. Claims 1-14 and 40 stand rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Srinivas⁴ and Tripathy.⁵

The critical argument raised by Fan is that the Examiner failed to establish that the ligno-sulfonate polyaniline complex taught by Tripathy would have been recognized by persons skilled in the art as a material equivalent to the conductive binders used in the anode catalyst layers of fuel cells described by Srinivas. More particularly, according to Fan, the suggestion that a conductive material might be useful in a battery would not have suggested that such a material would have been useful in a fuel cell. Fan argues that the electrochemical environment and the operating conditions of a battery are substantially different from those in a fuel cell. Batteries, for example, do not convert fuels to electricity, as do fuel cells. (Br. 8.) Thus, Fan concludes, the Examiner has not shown that lignin would have been recognized as a material suitable for use in a fuel cell. (Br. para. bridging 9-10.)

B. Discussion

Findings of fact throughout this Opinion are supported by a preponderance of the evidence of record.

³ Examiner's Answer mailed 23 May 2008. ("Ans.")

⁴ Bollepalli Srinivas, *Sulfonated Conduction Polymer-Grafted Carbon Material for Fuel Cell Applications*, U.S. Patent Application Publication US 2004/0110051 A1 (10 June 2004).

⁵ Sukant Tripathy et al., *Polymerization of Aromatic Monomers Using Derivatives of Hematin*, U.S. Patent Application Publication US 2002/0183470 A1 (5 December 2002).

Srinivas describes sulfonated polymer-grafted carbon materials that are said to be useful as the support material in catalysts in polymer electrolyte membrane (“PEM”) fuel cells. (Srinivas 3, [0036] and [0041].) In particular, the polymer-grafted carbon materials are prepared by oxidative polymerization of a monomer containing heteroatoms in the presence of a carbonaceous material (*id.* at 10, [0189]) such as carbon black (*id.* at 6, [0115]) or other high surface area electronically conductive carbon materials (*id.* at 7, [0124]). The polymerization can be followed by direct sulfonation (*id.* at 10, [0192]), or a sulfonated monomer can be polymerized (*id.* at [0193]). As a result, both the electrical and protonic conductivity of the catalytic support material is said to be increased. (*Id.* at 3, [0030].) Moreover, the porosity of the carbon support is said to be reduced, thereby increasing the metal [catalyst] availability for electrode reaction. (*Id.*)

Tripathy describes methods of polymerizing aromatic monomers such as aniline (Tripathy 2, [0036]) in reactions catalyzed by an assembled hematin or a derivatized hematin⁶ (*id.* at [0031]). In a preferred embodiment, anionic or cationic polyelectrolytes serve as templates along which the aromatic monomers align by ionic binding before polymerizing. (*Id.* at [0038].) Lignin sulfonic acid is described as a preferred anionic polymer template (*id.* at 3, [0039]), and Example 4 (*id.* at 5, [0069]-6, [0070]) illustrates the synthesis of a lignosulfonate-polyaniline complex. The conductive polymers are said to be useful in a variety of electronic devices, including displays and light weight batteries. (*Id.* at 1, [0003].)

⁶ Hematin is hydroxy-heme, a porphyrin in which the central metal atom is iron in the III oxidation state bonded to an axial hydroxy group.

It has long been recognized that it is obvious to replace a first material by a second material known to have equivalent structural and functional properties. *E.g.*, *Hotchkiss v. Greenwood*, 52 U.S. 248, 253 (1850) (“the knob of clay was simply the substitution of one material for another [porcelain].”) In the present case, the Examiner relies on the undisputed, common functional property of electron and proton conductance as evidence of equivalence of the sulfonated conducting polymers grafted to high surface area carbons described by Srinivas, and the sulfonated conductive polyanilines grafted to lignin taught by Tripathy. (FR, para. bridging 3-4; Ans. 4.)⁷ The Examiner has not explained, however, why persons having ordinary skill in the art would have recognized that lignin or polyaniline-grafted lignin would have been suitable for use as a catalyst support in the fuel cells described Srinivas. Moreover, the Examiner has not explained why the common proton- and electron-conductance would have sufficed to establish equivalence in view of the different electrochemical and operating conditions cited by Fan.

The Examiner’s reliance on the undated page of the Sigma-Aldrich catalog as evidence of equivalence is inadequate for several reasons. First, as Fan points out (Br. 13-14), the absence of a date prevents us from making the potential finding of fact that the argued equivalence was known prior to Fan’s filing date. Second, as Fan also points out (Br. 15), the presence of the tab-label “Fuel Cell/Battery Materials” in the margin of the catalog does not

⁷ The Examiner’s citation of Tripathy 1, ¶ [0011] (FR 4; Ans. 3) appears to be a typographical error or a conflation of the “assembled hematin” polymerization catalysts described by Tripathy (layers of hematin alternating with layers of polyelectrolyte) and the Pt catalysts described by Srinivas.

establish that the materials listed on the page were necessarily recognized as being useful for both of those purposes. Indeed, the only express suggestions for use on the page (under “Polyaniline (emeraldine salt),” right column) are for “electromagnetic shielding, charge dissipation, electrodes, batteries and sensors.” The suggestion of use in fuel cells is conspicuous, in the present context, by its absence. There are many reasons the purveyor of chemical products might group similar materials together, particularly when those materials are a small part of a very large inventory. A common, somewhat unusual group, such as electrically conducting organic materials, might suffice to alert persons—especially the sophisticated customers consulting a chemical catalog—that such materials are available for a variety of non-equivalent uses. Thus, even if the catalog were shown to present information known publicly as of Fan’s filing date, that evidence, without more, would not be probative of the equivalence argued by the Examiner.

Fan’s further arguments for the patentability of claims 40 and 14 are noted, but as those arguments are in addition to the arguments for the patentability of claim 1, we need not address them to determine that the rejection of all of the appealed the claims is REVERSED.

C. Order

We REVERSE the rejection of claims 1-14 and 40 under 35 U.S.C. § 103(a) in view of the combined teachings of Srinivas and Tripathy.

REVERSED

Appeal 2009-004576
Application 10/642,852

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